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THE ARGENTINE ANT:[1] DISTRIBUTION AND CONTROL IN THE UNITED STATES.

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INTRODUCTION.

The Argentine ant[2] is one of the most serious of household pests. Any exposed food or food refuse in the infested sections attracts the workers of this species in abundance, and residents and keepers of grocery stores, meat markets, confectioneries, etc., must either suffer considerably or almost constantly use poison or barriers of various kinds. If its activities were confined to the household only, the problem of controlling the Argentine ant would be sufficiently difficult, but in common with some other ants it has the habit of protecting mealybugs and aphids and thus indirectly becomes a pest of crops.

The problem is more serious from the fact that the species is steadily spreading in all directions throughout the Southern States. It is practically certain that it was introduced into this country at New Orleans, in ships which brought coffee from ports in Brazil, although the exact date of this introduction will always remain in doubt.

The Argentine ant was first observed in New Orleans in 1891 by Mr. Edward Foster.[3] At that time he records it in small numbers

[1] The work of the Bureau of Entomology on the Argentine ant is divided into two parts. One part deals with the ant as a general pest, its distribution, and relation to the cultivation of sugar cane. The other part relates to the special problem of control in citrus groves. This phase will be treated in another publication. The work reported in this paper does not include reference to conditions in California, parts of which State are also infested by the Argentine ant.

[2] *Iridomyrmex humilis* Mayr.

[3] Foster, E. The introduction of *Iridomyrmex humilis* (Mayr) into New Orleans. Jour. Econ. Ent., v. 1, no. 5, p. 289–293. 1908.

nine blocks east of the wharves at which the coffee ships usually discharged their cargoes. It may be surmised, from the knowledge we have since gained from studying the natural dispersion of this insect, that it has been in the country for about 45 years. During that period it has expanded from the original colony to myriads of colonies, extending its area of distribution into nine Southern States, the many infestations covering a total area of considerably more than a thousand square miles.

PRESENT KNOWN DISTRIBUTION IN THE SOUTHERN STATES.

Newell and Barber,[1] writing in 1913, recorded the known distribution in the Southern States as confined to Louisiana, Mississippi,

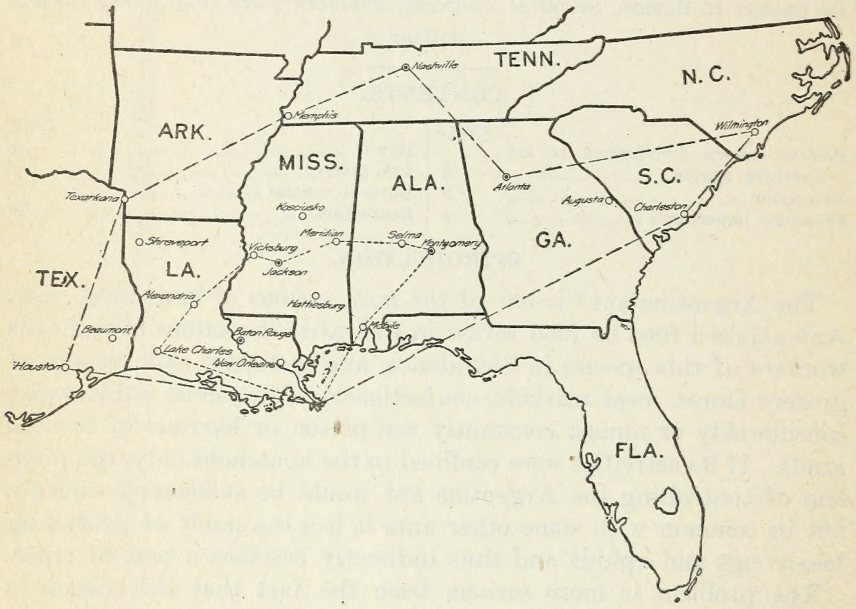

FIG. 1.—Map showing the distribution of the Argentine ant in 1913 (inner line of small dashes) and at the end of 1915 (outer line of longer dashes). (Original.) The outer line has been drawn merely to connect the outlying points. It incloses some territory in which the ant is not known to occur, as, for instance, western Florida.

and Alabama, and established the limits of this dispersion from Montgomery, Ala., on the east, to Lake Charles, La., on the west, a distance of 380 miles, and from Delta, La., on the north, to the mouth of the Mississippi River, a distance of 250 miles. At the present time the limits of the distribution are from Houston, Tex., on the west, to Wilmington, N. C., on the east, and from Nashville, Tenn., to the mouth of the Mississippi River, a distance of 1,100 miles east and west and 500 miles north and south (map, fig. 1). Among the cities known to be infested are Houston, Tex., Shreveport, La.,

[1] Newell, Wilmon, and Barber, T. C. The Argentine Ant. U. S. Dept. Agr. Bur. Ent. Bul. 122, p. 14. 1913.

Texarkana, Ark., Nashville, Tenn., Memphis, Tenn., Augusta, Ga., Atlanta, Ga., Charleston, S. C., and Wilmington, N. C.

DISPERSION.

Under natural conditions the Argentine ant spreads very slowly, and this spread is controlled to a large degree by the available food supply. Like most other species of ants, the Argentine ant is a very industrious forager, and a shortage of food tends to hasten its dispersion. In October, 1914, a small infestation covering the most of two city blocks was found in Memphis, Tenn. The ant numbers could not have increased to any appreciable extent during the rather long and cold winter of 1914–15, and yet in the early part of the following June the infestation was found to involve nearly the whole of five blocks. In October, 1915, it developed that the boundaries had not been extended, though the ant numbers had greatly increased. The food supply must have increased as fast as did the numbers of ants.

In several instances frequent observations made at points on the frontier of the infestation developed the fact that the normal advance will average from 300 to 400 feet a year. The abundance of native ants has some influence on this advance, since the Argentine ant will not tolerate any of the native species, and in consequence a continuous fight is waged all along the frontier.

Heavy, flooding rains are undoubtedly a factor in the natural distribution of this ant, and in the vast region drained by the Mississippi River and its tributaries it will be remembered that there are at least two dangerous flood seasons and sometimes more, which contribute to and accelerate the distribution of this species. Lumber, rotting trees, uprooted shrubs, cane growth, fruit, vegetables, and all manner of refuse contribute to the mass of matter borne on the crest of flood water, and in this the ants seek refuge and are involuntarily transported. Nature has endowed this species with a remarkable habit of self-preservation from drowning in times of floods, for when rising water floods their nests and no other means of escape are presented they cluster together and form a compact ball. The immature stages form the center of this ball, with the queens and workers as the outer portion. As the ball enlarges from the addition of other workers which had been struggling alone in the water it gradually revolves. It is kept revolving slowly by the outside workers continually striving to reach the top of the ball, thus permitting air to reach the interior. The writer has had only one opportunity of witnessing the formation of a ball of this kind. After a 5-inch rainfall several balls, none more than 2 inches in diameter, were observed. According to reliable authorities, such balls have been observed on many occasions, some of them from 6 to 8 inches in diameter. The ants in

these balls disperse when they come into contact with a secure resting place, such as a floating piece of timber or land, but they have been seen to float around for hours on still water. Mr. Smith, at Daisy, La., states that he destroyed a large number of these balls by pouring some coal oil on the water. The balls quickly broke up when in contact with the oil and the ants died in a very short time.

Driftwood is another important carrier of this pest. A fallen decayed log is an ideal nesting place. Such a log will usually decay from the underside upward, the upperside or top making a roof for the nest, with the rotted wood below drawing and retaining ample moisture, thus affording excellent material in which to make galleries. Logs of this kind are light and easily floated and are important factors in spreading infestations. Especially is this the case in those parts of the country where heavy, flooding rains occur. In this manner practically all the land along the Mississippi River below New Orleans has been infested.

However, it is to the vehicles of man that the greatest distribution must be credited. The most important are steamboats and railroads. Commodities are carried from infested territory to uninfested places and ant colonies are often to be found in shipping boxes, feeding on sugar and other grocery supplies. Practically every one of nearly a hundred steamboats landing between New Orleans and Baton Rouge is infested with the Argentine ant. Further, it seems likely that this ant was carried by boat from Charleston, S. C., to Wilmington, N. C., as the ant is to be found around the wharves and shipping in both places. So gross is the infestation in both these cities that it is possible that the species may have been introduced into Charleston many years ago on coffee ships, as it is supposed to have been introduced into New Orleans, the slightly colder winters holding it more in check.

When inspecting cities far removed from New Orleans it has been found that in the great majority of instances the infestations start immediately around the wholesale-grocery and commission-merchant establishments. This indicates that when carried long distances the ants are more likely to be taken through in solid carload lots of merchandise which are rushed to their destination than in smaller consignments. This is especially the case with perishable goods such as fruit and vegetables. Cars containing broken shipments are sidetracked at the first town to which goods are consigned, and the ants present are likely to leave the car at the first or second stop, which fact is verified in that nearly all the small towns for a distance of 150 miles from New Orleans are infested. A serious feature of the infestation of inland cities such as Texarkana, Memphis, Atlanta, and others, is that the ants, having become established in the wholesale district, are readily distributed to surrounding smaller towns

which are tributary to these centers. A point where such a distribution has occurred is Summerville, a little town 24 miles north of Charleston, S. C., which has become infested, presumably, from the latter place.

In a complete colony in the spring of the year three distinct forms of adults are to be found—queens, males (drones), and workers, the workers greatly outnumbering both the queens and the males. The workers, foragers of the colony, are imperfect females with no reproductive functions. The queens, which are the reproducing females, remain within the nest nearly all the time, and are fed and tended by the workers. The males have apparently but one function—that of fertilizing the queens. It will be readily understood that, as in the social economy of ant communities of other species, it is absolutely necessary that a fertilized queen be taken along with a number of workers before a new colony can be started. It is quite possible that almost every town and city in the Southern States has had a number of workers introduced at one time or another, but owing to the absence of a queen a noticeable infestation has not become established. Workers alone carried in this manner would die out. Such may be the case at Nashville, Tenn., where only a few workers have been found. Later observations will be necessary to decide this question.

ECONOMIC IMPORTANCE.

As a pest in cities the Argentine ant has no equal. Owing to its small size and unobtrusive color, it is able to invade practically every part of ordinary dwellings, stores, etc. It is almost omnivorous, eating most cooked foods and a considerable percentage of the raw foods that are to be found in the average pantry. It exhibits a marked preference for some foods, such as sugar, sirup, honey, jams, cakes, candies, pies, fruit, and meats of all kinds. The temperature of refrigerators or ice boxes seems to have no deterrent effect, and ants will readily invade them.

It is a common occurrence for Argentine ants to invade bedchambers, and while they do not possess a sting, they can cause considerable pain with their mandibles. There have been many reports of babies being attacked by them in such numbers as to cause serious results, and several of these reports have been verified. In August, 1915, the writer located such a case in Augusta, Ga. A reputable citizen of that city, residing in a heavy infestation of the Argentine ants, gave the following account of such an attack on his 4-weeks-old baby:

> We were awakened in the night by a weak cry from the baby, and when the light was turned on the baby's face was black with ants. They were in the baby's nose, ears, and mouth. We hurriedly carried the baby to the bathtub

and started to wash off the ants. It took us nearly an hour and a half to get the last ant off the baby. I feel sure that if we had not heard the cry, in a few hours the child would have perished.

With conditions made almost intolerable in badly infested places, it is not uncommon to find empty, unrentable houses. Realty values accordingly drop.

The nurseryman and truck grower are greatly molested by this pest, owing to the ant's fondness for the honeydew of aphids and scale insects. The ants take the best possible care of these honey-yielding species, and protect them from their natural enemies, frequently building mud shelters over them, and as the host plants grow, carry the young scales and aphids and place them on the young tender growth, where they may more easily sap the juices of the plants.

Newell and Barber[1] give a very graphic account of the manner in which the Argentine ant has invaded the orange orchards of Louisiana.

In corn, cotton, and sugar-cane fields the Argentine ant when present is constantly attending the aphids and mealy bugs, increasing the numbers of these species to an alarming degree, much to the detriment of the plants. The writer has determined that a considerable loss of sugar results from the attendance of the Argentine ant on the sugar-cane mealy bug.

HABITS.

Argentine ants are extremely social among their own kind, the individuals never having been observed to quarrel with one another, nor one colony with another. Workers may be carried for miles and placed with others of their kind and no apparent demonstrations of like or dislike are exhibited. The newcomers appear to enter into the colony spirit and are soon lost to the view of an observer. Any small nest will contain several queens which live together amicably.

The summer nest may be located anywhere—under sidewalks, under the sills of houses, in brick piles, stone piles, under a piece of board or a piece of tin, in an old tin can—in fact, in any place convenient to the food supply. In the winter months there is a tendency to concentrate into larger colonies, and they seek warm, dry, secure nesting places in which to hibernate. These desirable places are not plentiful, and where one is located the ants from some distance will seek its shelter. The winter is the most hazardous period of the year, for should a nest by any chance be flooded during a cold spell, when the ants are dormant, the chances of survival of the colony would be extremely slight. Usually throughout the latter part of December,

[1] Op. cit., p. 24.

January, and February (at New Orleans) these large colonies are found. They sometimes reach very extensive proportions and may contain several hundred queens and countless workers and immature stages. These colonies are usually located at the base of large trees on high, well-drained spots of ground, in manure piles, or in any other piles of decomposing rubbish where heat is generated. A warm day will make them particularly active, and they will form trails in all directions from these winter nests to food supplies. They may be observed traversing the trunks of trees every warm winter day, and from the trees trails are made to nearby houses, where they cause considerable annoyance.

With the advent of warm spring weather the breaking up of the large colonies occurs. This is the time of the year that food is very scarce, and at this season the ants are particularly aggressive and troublesome in the houses. *This is the best time to use poisoned sirup, which will be described later, for controlling this pest.*

LIFE HISTORY.

There are three adult forms to be found within a complete nest in the spring months of the year—the queen, the male, and the worker. A colony may be complete, however, with a queen and workers. Three immature forms are also present—the egg, larva, and pupa.

EGG.

In an artificial formicary a fertilized queen lays from 3 to 30 eggs per day when ample food is supplied. It is very probable that under natural conditions the egg production is considerably more. Only a few seconds are occupied for the laying of each egg. A worker, apparently awaiting the arrival of the egg, picks it up and transfers it to a pile of eggs already in the nest. The surface of the egg is somewhat mucilaginous and readily sticks to other eggs. This permits the workers to handle the eggs en masse and also permits of their being deposited in desirable locations on the walls and ceilings of the galleries.

The egg when first laid is about 0.3 mm. long and 0.2 mm. wide. It is elliptical, pearly white, lustrous, and without markings. As the time for hatching approaches the luster disappears. It is extremely difficult to detect the exact time of hatching. The average summer incubation period is about 15 days, but this, of course, is subject to the variations of temperature and humidity during this period.

LARVA.

The larva, when first hatched, is creamy white. Its body is very curved, but it gradually straightens as the larval growth continues. It is entirely helpless and is practically motionless.

The workers feed and cleanse the larvæ, moving them about with the fluctuations of temperature and humidity to the most desirable places within the nest. The full-grown worker larva is about 1.5 mm. long by 0.65 mm. wide. The average larval period throughout the summer months under normal conditions is about 13 days.

PUPA.

When the pupal stage is reached the sex of the individual is readily distinguishable. The pupa is white, with the exception of two distinct black eyespots on the sides of the head. The worker pupa is about 2 mm. long, the head and thorax being the larger part of it. The male pupa is about 50 per cent larger than the worker pupa, and the queen is still larger. The two latter forms may be readily distinguished from the worker pupa. The male pupa has a very large thorax and a small, closely coupled abdomen, while the queen pupa is much more symmetrical, the thorax is not so large, and the abdomen much larger than that of the male. The pedicel between the thorax and abdomen of the queen pupa is more constricted and elongated than in the male pupa.

After the first few days the color of the pupa gradually changes to creamy yellow and continues to darken until a light-brown color is reached just previous to emergence.

The duration of the pupal stage of the worker throughout the summer months averages about 13 days, while that of the male is about 22 days. No records have been established of the duration of the pupal period of the queen.

The pupæ of all the stages are aided in transformation by the workers. Upon first emerging the adult is of a light-brown color which gradually grows darker until the second day, when it becomes indistinguishable from other adults.

DEVELOPMENTAL PERIOD.

By compounding the average periods of development of the egg, larva, and pupa, a general average of 40 days results, which represents the complete development from egg to adult in the case of the worker and a somewhat longer period for the males and queens.

ADULT FORMS.

The worker is about 2.5 mm. in length and of a dark-brown color, and there is only one caste. The workers forage for food, attend the queen and the young, and fight to protect the colony. A large percentage of the workers stay within the nest at all times and are always ready for any emergency, whether it be to fight invaders or to hurriedly seize the immature stages and retreat to securer locations upon the slightest indications of rain or flood.

The workers are able to carry considerable liquid food in their abdomens, which become distended and transparent. This food is regurgitated when the nest is reached, and fed to the immature forms and other workers and queens in the nest. They are quite long lived and have been kept in artificial formicaries for many months at a time. It is quite possible that they may live a year under natural conditions.

The male is always winged. It is readily distinguished by its massive thorax, small head, and abdomen. It is about 3 mm. in length, and the body color is of a dark brown, the same shade as the worker. Males appear in the nest in the spring months of the year and gradually lessen in numbers as the summer advances.

When the queen first emerges she is winged, but at the time of copulation, or about that time, she loses her wings, and her activities from that time are devoted to egg producing. The deälated queen is about 6 mm. long and of the same color as males and workers. It is seldom that the queens leave the nest unless disturbed, but occasionally they may be seen crawling along an ant trail in company with the workers. At rare intervals they travel alone and may be observed wandering about aimlessly.

The queens have frequently been kept within artificial formicaries for more than a year, and it is reasonable to suppose that they will live much longer.

NATURAL CONTROL.

It would appear that heavy rains and resulting flood are the only factors of natural control of any great importance. They are especially effective if occurring during cold weather, for at this time the ants are sluggish and unable to exert themselves. Moderately cold weather does not appear to check their activities.

On November 18, 1911, a heavy infestation of this ant was discovered at Kosciusko, Miss., about half the town being infested. Residents stated that they had been troubled for about 7 years; several of them, owing to the great annoyance, had moved to parts of the town which were not then infested. On revisiting Kosciusko in April, 1912, the infestation had decreased to such an extent that it was quite difficult to find any of the ants. The meteorological records of the winter months revealed the following striking facts: The mean average temperature of the 6 months from November to April, inclusive, was 49.5°, but the rainfall for this period was excessive, reaching the total of 41.1 inches, whereas the average 10 years' precipitation for these months had been only 27 inches. This control was, however, only temporary. In June, 1915, Kosciusko was again visited and the ants were found to be very numerous and causing great annoyance to residents. The infestation had spread

over practically the whole town, as well as near-by corn and cotton fields.

During the same winter (1911–12) similar conditions were experienced at New Orleans, the winter months being accompanied by a rainfall of 41.56 inches, as compared to the 10-year average of but 26.1 inches. The numbers of ants were greatly reduced, the mortality probably being at least 70 per cent. The ability of this species to overcome such a catastrophe was well illustrated, for by September, 1912, the ants had apparently reached their maximum numbers.

REPRESSION.

OUTDOOR BARRIERS.

A number of experiments have been conducted to discover, if possible, an efficient outdoor barrier.

The sticky substance which is used in coating flypaper and is also sold in bulk for banding trees was effective for only a few days. The ants would carry particles of dirt and build a bridge over it. This substance, made much thinner than usual, as suggested by Mr. D. M. Rogers for use in the gipsy-moth work, was tried and with more successful results. Heavy bands 4 inches wide spread on two magnolia trees were effective for two months in the summer without having to be replenished or combed.[1]

In the cooler parts of the year these bands require frequent attention on account of the growth of mold on the surface. During wet weather in the winter in Louisiana this mold will form in a very few days, and the efficiency of the sticky band will be entirely destroyed.

It was found that 5 per cent of a carbolized oil added to the thinner preparation increased the effectiveness of the bands considerably and entirely prevented the growth of mold. The bands were also rendered more repellent and more resistant to winter conditions. A thin crust forms over the surface of the bands in the winter, but this is readily combed into the band in the spring and the band is as effective as ever. The crust on bands of the thinner preparation without the carbolized oil becomes too hard during the winter, and it is necessary to use fresh material in the spring. These bands were used on fig, magnolia, pecan, and orange trees and no injury to the trees was apparent. There is a possibility that the substance may be harmful to trees with a more tender bark, however.

To the thinner preparation were added in different tests 1 per cent of bichlorid of mercury, 2 per cent of nicotine sulphate, 10 per

[1] A wooden comb is supplied by the manufacturers for the purpose of combing the bands when a coating of dirt, insects, or any other foreign matter collects on the band. This foreign material is mixed in with a clean sticky substance, immediately under the surface of the band, and the band is as efficient as ever.

cent of naphthalene, and several other repellents. While bands containing bichlorid of mercury and nicotine sulphate were effective for slightly longer periods than the sticky substance alone, their use is hardly to be recommended.

INDOOR BARRIERS.

Perhaps the most effective and durable barrier which can be used indoors is a bichlorid-of-mercury tape or band. Tape is soaked in a saturated solution of bichlorid of mercury and then hung up to dry. It is then placed around the legs of tables, safes, etc., and if it is kept dry will last from six months to a year. Common lampwick one-half an inch wide is ideal for this purpose. After it has been treated in a saturated solution of bichlorid of mercury and dried, pieces are wrapped around the leg of the piece of furniture to be isolated and ends lapped over tightly and pinned. The tape can be readily renewed by another soaking in bichlorid of mercury and repinned in place.

Twenty-five per cent of bichlorid of mercury mixed in shellac may be painted around the legs of furniture, and when dry it will be quite as satisfactory as the tape.

Extreme caution is advised in handling bichlorid of mercury, as there is always an element of danger in using this poison. In recent years the sale of this drug to the layman has been practically discontinued.

A simple and efficient, though perhaps unsightly, barrier may be made by placing the legs of furniture in saucers and putting a generous supply of moth balls in each saucer. The moth balls will slowly volatilize, and it is necessary to add more from time to time, but the ants will not cross the barrier thus formed.

Coal oil placed in saucers in which the legs of furniture rest will repel the ant, but the odor of the oil is disagreeable to most persons.

ANT POISONS.

Many and varied experiments have proved that it is futile to try to exterminate Argentine ants with a poison which kills rapidly. A few workers may be killed, but the masses of ants will quickly recognize the source of fatality and avoid the "doctored" food. The few workers killed in this way will have no effect in reducing the numbers. None of this poison will reach the queens in the nest, and it has been found that it is essential to kill off the queens in order to prevent further multiplication of the pest.

Soon after the writer took up the work on the Argentine ant Mr. L. J. Nickels[1] published an article on the control of the Argentine ant in California, in which a rather successful poisoned sirup was described. It was decided to give this poisoned sirup a thorough trial

[1] Nickels, L. J. Field Work in the Control of the Argentine Ant. Jour. Econ. Ent., v. 4, no. 4, pp. 353–358. 1911.

in the Southern States. The following experiment is based on Mr. Nickels's recommendations:

EXPERIMENT AT HATTIESBURG, MISS.

At Hattiesburg, Miss., an infestation of 8 blocks was found to be an ideal place for this experiment.

The following buildings were located within the infestation: Thirty-eight residences, 7 stores, 2 meat markets, 2 small hotels, 2 restaurants, 2 bottling establishments (which will be designated hereafter as establishment A and establishment B), a laundry, a marble factory, a sawmill and office, and a church.

Thirty dozen 1-pint fruit jars were prepared in the manner outlined by Mr. Nickels. The porcelain was broken out of the metal tops and five holes about three-eighths inch in diameter were punched near the center of each top. Sponges were cut up into pieces and a piece inserted in each jar. The piece of sponge filled about a third of the space in the jar.

A gill of the poisoned sirup was put into each jar. On each jar was pasted a poison label.

On September 28, 25 dozen of these jars were distributed—about six jars placed in each house and store. Two vacant blocks were not covered at this time, but on November 16, 3 dozen jars were distributed on these blocks. As the jars had to be placed outdoors, they were laid on one side to prevent rain from entering. The residents of the other blocks were questioned as to results, and they reported very favorably. In most cases the ants had become much less abundant. The two meat markets had fewer ants than before, but the sirup rooms of both bottling establishments were as badly infested as ever, the ants evidently preferring the flavored sirups to the poisoned sirup.

In the latter part of April, 1912, the infestation was again determined. This was immediately after the winter previously referred to, when the infestation had been so reduced at Kosciusko and New Orleans. Though the numbers of ants had certainly been reduced in Hattiesburg, they were still present in proportionately greater numbers than in New Orleans. It is likely that the better wintering facilities at Hattiesburg were due particularly to excellent drainage and the presence of numerous trees.

On June 18 another inspection was made. The numbers of ants were at this time about 60 per cent of what they were during the previous November. The eastern line of infestation had not been extended and the ants were giving little trouble in the houses, though they had apparently concentrated around the sirup rooms of both bottling establishments. The stores and meat markets had not been troubled to any extent, but there were many trails of ants on the trees. Many of the jars were examined, and it was found that a de-

composition had taken place in the sirup in the jars, a very disagreeable odor being given off. As many of the jars as could be found were collected. These were thoroughly cleaned, especially the sponges, which were washed in boiling water. Fresh sirup was prepared and the jars recharged and again distributed.

The jars were again recharged in October. At this time, though the infestation had not spread, the ants were more numerous. They were very numerous in the sirup rooms of both bottling establishments, and in both meat markets.

Observations were made in December, and at this time conditions were fairly satisfactory. Ants had troubled only two of the houses, in each instance only for a day or so, and had then left. The bottling establishments were closed for the winter. The intention was to recharge the jars at this time, but the status was so satisfactory that it was decided to leave them until the following spring.

In the beginning of April the ants were not very plentiful. Only three houses had been invaded during the winter. The sirup rooms of both bottling works were again besieged.

By the latter part of May the ants were more numerous all over the infested area, though none of the residents or storekeepers had so far been troubled. The proprietor of bottling establishment A now had his sirups isolated and the ants were noticeably fewer around this building, but they were in increased numbers around the other plant. The ants were now very numerous on one block, and as the jars had not been satisfactory outdoors, special paraffin-covered rainproof paper bags were prepared to place on the trees near the houses and along the streets throughout the infested area. The experiment had been conducted for 20 months and the results had not been entirely satisfactory. The ants had been almost completely kept out of the houses and stores, except the sirup rooms of the bottling works, but large numbers were still present outdoors.

It is fairly conclusive that the sirup within the houses repelled the ants, for even in the spring the ants gave little trouble to the residents.

On July 9, 50 paper bags[1] containing this sirup were placed on trees throughout the infested area. About half of these bags were placed on trees in one block. All the bags were tacked about 15 feet above the ground to keep them out of reach of children and to arrest evaporation as much as possible, bags at this height being in the shade.

On August 13 a status inspection was made, and very remarkable results were observed. There were not at this time more than 20 per cent of the ants on the trees as compared with July, and all of the houses without exception situated anywhere near the trees had

[1] A description of the preparation of this bag is given on pages 20 and 21.

been invaded. None of the stores along Bay Street, near which were no trees, had been bothered by the ants. All the jars were recharged.

In November conditions were very satisfactory. Comparatively few ants were to be seen, and these were mostly on the trees. No ants were to be found in the sirup room of bottling establishment A, and there were very few in the vicinity of the building. There were very few ants on the trees in one block. By far the largest number of ants were to be found around the building in which bottling establishment B had been located. People in the house next to this building were being considerably troubled.

In January, 1914, all the jars were recharged and 150 paper bags containing the poisoned sirup were distributed over the infested area.

On April 7 a thorough inspection was made, and the numbers of ants were found to be greatly reduced. Nowhere had the ants caused any annoyance. There were very few ants on any of the trees. In several places native ants had again taken up their abode within the infested area, indicating that the Argentine species was dying out.

In the latter part of May the jars were recharged and 300 poison bags placed in suitable locations. An inspection at that date proved that the experiment was continuing very satisfactorily.

Native ant nests could be found dotted over the whole area. The largest number of Argentine ants was found around the abandoned building of bottling establishment B; in fact, this was the only place where the ant could be found in large numbers.

An inspection on June 29 indicated that the experiment was progressing favorably. The numbers of Argentine ants around bottling establishment B had greatly decreased, it being actually difficult to find them on these premises. Not a vestige of the infestation could be found on three of the blocks.

In mid-September the territory was again inspected. The conditions were found to be excellent. Scarcely an Argentine ant could be seen in any part of the once-infested territory.

Everyone living in the formerly infested area was of the opinion that the Argentine ants had been completely eradicated, but the writer found a few workers. However, he decided to consider the experiment concluded, for the time at least. It was possible that the queens were all destroyed and that just a few workers remained. There was also the possibility of the native ants finally exterminating the Argentine species.

The poisoned sirup had finally proved efficient, though it must be stated that it was necessary to expose it both indoors and out.

IMPROVEMENT OF THE NICKELS SIRUP.

In the tests with the Nickels sirup a number of objectionable features were encountered which finally led to the preparation of a

greatly modified sirup. In all the experiments the sirup proved very attractive and palatable to the ants at first, but their visits gradually decreased until the sirup was avoided, although in some instances the trails continued to pass by the poison jars. The period of attendance at the sirup varied somewhat with the seasons, being longer in winter. Even in the winter, however, a repellent action was apparent. In preparing the solution it had been noticed that the sirup turned brown, becoming darker the longer it was boiled, although it was made in a pail which in turn was placed in a bath to prevent burning.

Another objection was the crystallization of the sirup to a greater or less extent upon cooling. On the advice of a sugar chemist the proportion of water was increased to make a saturated sugar solution; 10 pounds of water to 20 pounds of sugar and 1 ounce of sodium arsenite were used. The Nickels sirup contained one-fourth per cent arsenic, while this more dilute sirup contained one-fifth per cent, but the dilute sirup was quite effective. With the exception of the first application, the dilute sirup was used throughout the length of the Hattiesburg experiment. Crystallization of from 5 to 15 per cent of the weight of sirup still occurred in short periods, but as high as 50 per cent when the sirup had been in the jars for several months. This of course had the effect of proportionally increasing the percentage of poison in the liquid and consequently its repellent power. Newly made sirup appeared to be less repellent than that which had stood for several weeks.

The repellent action of the sirup is illustrated by an experiment conducted in a private residence, which was badly overrun with ants. The ants were abundant in the refrigerator, safe, and sink, and literally covered the floors. Six fruit jars containing the Nickels sirup and sponges were placed in different rooms in the house, and 6 paraffined paper bags containing the same sirup and a sponge were placed around the house outdoors on trees, fence, and back porch. The sirup was about a month old. The experiment was begun at 1 p. m. At 5 p. m. hardly an ant was to be seen in the house, although a few were to be found at each jar and many were visiting the bags. Two days later not an ant could be found in the house and only three of the bags were attended by ants. As it seemed impossible that the colonies could have been exterminated so quickly, the adjacent vacant lot was inspected. This lot was overgrown with weeds, and in a corner near the house there was a pile of old lumber. Ants were found in abundance nesting in the lumber, and many were present wherever they could find dry quarters in the lot. It was quite evident that the ants had been repelled by the poison.

A series of experiments to obtain definite data on the repellent properties of the sirup were conducted in the Horticultural Hall,

Audubon Park, New Orleans, with the Nickels sirup in the strength as recommended originally, and also double, half, and quarter strengths. One gill of sirup was used to a jar, each jar being placed on its side to give free access to the ants, to prevent the entrance of water, and to prevent mold. The "Hall" furnished ideal conditions for the experiment, the temperature throughout the year being kept high and uniform. The abundance of various species of scale insects and aphids attracted the ants in great numbers at all seasons, but especially in cold and wet weather. Three jars of each strength were used and observations were made frequently for a period of 32 days. At the time of this experiment the ants were very numerous, due to the extremely wet summer of 1912. The rate of attendance and relative repellent value of the four strengths of the poison are shown graphically in the first part of Table I.

TABLE I.—*Experiments with sodium arsenite ($NaAsO_2$) added (in four strengths*[1]*) to sugar sirup solution, 1912.*

[Symbols: A=Heavily visited by ants. B=Only attended by a few ants. C=Not attended by ants.]

FIRST TEST, IN HORTICULTURAL HALL.

Date.	Double strength.			Nickels solution.			Half strength.			Quarter strength		
June 8	A	A	A	A	A	A	A	A	A	A	A	A
June 10	A	B	A	B	A	A	A	A	A	A	A	A
June 12	B	B	B	B	A	A	A	A	A	A	A	A
June 13	A	B	A	A	A	A	A	A	A	B	A	A
June 14	B	C	B	B	A	A	A	A	B	A	A	A
June 15	B	C	A	A	A	A	A	A	A	A	A	A
June 17	B	A	A	A	A	A	A	B	A	C	A	A
June 19	A	B	B	A	A	A	A	A	A	A	A	A
June 21	B	B	A	A	A	A	A	A	A	A	A	A
June 22	B	A	A	C	A	A	A	A	A	A	A	A
June 26	A	C	B	B	C	C	A	A	C	C	A	A
June 28	C	C	A	C	A	B	A	C	A	C	A	A
July 1	B	A	B	C	A	C	A	C	A	C	A	A
July 2	C	B	C	C	A	C	A	A	C	C	A	B
July 5	C	B	C	C	C	A	A	B	A	C	A	A
July 8	C	C	C	C	C	A	A	A	C	C	A	A
July 10	C	C	C	C	C	A	A	B	A	A	C	A

DUPLICATE EXPERIMENT, USING PAPER-BAG SIRUP CONTAINERS TACKED ON FIG TREES (OUTDOORS).

July 26	A	A	C	A	A	B	A	A	A	A	C	A
July 28	B	B	C	B	B	B	A	A	B	A	A	A
July 29	A	A	B	B	A	A	A	A	A	A	A	A
July 30	A	B	C	C	A	A	A	A	B	A	A	A
July 31	C	B	C	B	A	B	A	A	A	A	A	A
August 1	C	A	C	B	B	A	A	A	A	A	A	A
August 2	C	C	C	C	B	A	A	A	A	A	A	A
August 3	B	C	C	A	A	A	A	A	A	A	A	A
August 5	A	A	C	A	B	B	A	B	A	A	A	A
August 12	A	A	C	A	A	A	A	A	A	A	B	A
August 14	B	B	C	A	A	A	A	A	A	A	A	A
August 16	B	C	A	A	A	B	A	A	A	A	A	A
August 19	B	B	C	A	B	B	A	A	A	A	A	A
August 21	C	C	B	B	A	C	A	A	B	A	A	A
August 23	B	C	C	A	A	B	A	B	A	A	B	A
August 26	A	C	B	A	A	A	A	B	A	A	A	A
August 29	A	B	C	A	B	C	A	A	B	A	A	A
August 31	A	A	C	A	B	B	A	B	A	A	A	A

[1] Double strength——10 pounds granulated sugar + 5 pounds H_2O + 1 ounce $NaAsO_2$.
Nickels solution——10 pounds granulated sugar + 5 pounds H_2O + ½ ounce $NaAsO_2$.
Half strength——10 pounds granulated sugar + 5 pounds H_2O + ¼ ounce $NaAsO_2$.
Quarter strength——10 pounds granulated sugar + 5 pounds H_2O + ⅛ ounce $NaAsO_2$.

The experiment was duplicated, except that the sirups were placed in waxed paper bags tacked on fig trees. These bags each held a gill of sirup, and sponges were placed in the sirup to allow easy access of the ants. At the time of conducting the experiment the figs were ripening and the ants were visiting the trees in immense numbers. It will be seen from the second part of Table I that the results were substantially the same as in the indoor experiments. The two experiments may be summarized as follows:

The most concentrated sirup (2 ounces sodium arsenite) attracted great numbers of ants in only 32 counts, few ants in 34 counts, and no ants whatever in 39 counts.

The standard Nickels sirup (1 ounce sodium arsenite) attracted great numbers in 62 counts, few ants in 25 counts, and no ants in 18 counts.

The half-strength solution ($\frac{1}{2}$ ounce sodium arsenite) attracted great numbers in 88 counts, few ants in 12 counts, and no ants in 5 counts.

The quarter-strength solution ($\frac{1}{4}$ ounce sodium arsenite) attracted great numbers in 92 counts, few ants in 4 counts, and no ants in 9 counts.

The experiments prove, therefore, that the excessive quantities of the arsenic in a sirup will cause it to become repellent. The observations also indicate that the sirup decomposed more rapidly as the amount of the sodium arsenite increased.

Dr. W. E. Cross, research chemist of the sugar experiment station at Audubon Park, was consulted with regard to the various defects in the Nickels sirup. His explanations and suggestions, which were of great importance in the further conduct of the investigations, are given below.

When granulated sugar (or sucrose) is heated, it is partially changed to invert sugar (or glucose), and if to this is added sodium arsenite, which has an alkaline reaction, chemical decomposition takes place. When heated this reaction is hastened and the compound becomes darker and darker. On account of the instability of the sirup, it will further decompose on standing and the final product will be a substance with an unpleasant odor and taste. The addition of a small quantity of tartaric acid to the sugar sirup before adding the sodium arsenite will produce a greater inversion of the sucrose, thus lessening the danger of crystallization, and will neutralize the alkalinity of the sodium arsenite, preventing decomposition. If a slight acid reaction is obtained the sirup will keep indefinitely. The inversion of the sucrose reduces the sweetness of the sirup, and to balance this 7 per cent of pure honey is added.

The preparation finally proposed by Dr. Cross is made as follows:

Prepare a sirup:

Granulated sugar	pounds	15
Water	pints	7
Tartaric acid (crystallized)[1]	ounce	¼
Boil for 30 minutes. Allow to cool.		
Dissolve sodium arsenite (C. P.)	ounce	¾
In hot water	pint	1
Cool.[2] Add poison solution to sirup and stir well. Add to the poisoned sirup:		
Honey	pounds	1½
Mix thoroughly.		

On April 23, 1914, Dr. Cross and the writer prepared two sirups of the above formula (exclusive of the honey, which only makes the sirup more palatable), except that one lacked the tartaric acid. After cooling, they were tested in a refractometer, with the following results:

Sirup with tartaric acid, specific gravity 1.339, Brix (sugar content) 68.8.
Sirup without tartartic acid (Nickels sirup), specific gravity 1.343, Brix 68.05.

The Nickels sirup had lost 0.75 per cent of its sugar content and was of a very dark brown color. The new sirup was bright yellow (amber color), clear, and transparent. Equal samples of each were placed in quart exhibit jars with ground-glass stoppers, labeled, and set aside. A second reading was made on June 20, 1914, as follows:

Sirup with tartaric acid, specific gravity 1.340, Brix 68.40.
Nickels sirup, specific gravity 1.3321, Brix 67.01.

The new sirup had lost 0.4 per cent of its total solids and had not noticeably changed in color or sweetness. The Nickels sirup had lost 1.04 per cent of its total solids, was nearly black, partly crystallized, and had lost much of its sweetness. In the beginning of August the stoppers were removed and cheesecloth tied over the mouths of both jars, to find how evaporation would affect these sirups. The jars were placed on a shelf in the laboratory. In the beginning of January, five months after the jars were first left open, they were examined. Figure 2 shows the conditions. The difference in the quantity of the sirups, in color, and in the crystallization that had taken place within the jar containing the Nickels sirup may readily be noted. A reading was taken of these sirups, as follows:

Sirup with tartaric acid, specific gravity 1.385, Brix 75.48.
Nickels sirup, 1.367, Brix 72.68.

[1] In the first experiments one-half ounce of tartaric acid was used, but this is found unnecessary.

[2] In earlier experiments the sirup was boiled 30 minutes after addition of the poison, but boiling will raise the "Brix" (total solids), which is to the disadvantage of the sirup as an ant bait.

The Nickels sirup[1] was then drained from its jar and was found to weigh 160 grams. The jar and crystals were then weighed, the crystals dissolved out of the jar, and the weight of the jar subtracted from the total weight of the jar and crystals. It was found that 333 grams of sugar crystals were present.

	Grams.
Weight of sirup when first made	660.23
Weight of sirup remaining + sugar crystals	493.00
Water passed off by evaporation	167.23

The 660.23 grams of sirup contained 1.333 grams of sodium arsenite with a poison content of 0.202 per cent.

The 160 grams of sirup remaining contained 1.333 grams of sodium arsenite. The poison content was now 0.836 per cent.

The sirup with tartaric acid had a small precipitation. As the Brix had been raised 7.4 per cent through evaporation, the poison content was very slightly raised. This sirup now weighed 643.35 grams, the color and sweetness being still quite stable.

Immediately after preparing these two sirups, April 23, 1914, 2 fruit jars of each, containing 1½ gills of sirup apiece (without honey), were set out along heavy ant trails in the Horticultural Hall. Absolutely clean and odorless sponges were used.

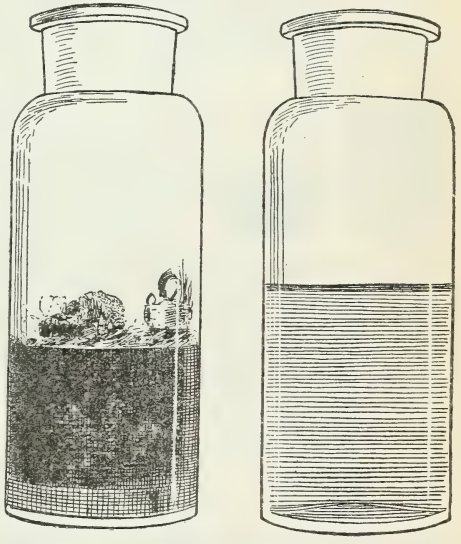

FIG. 2.—Comparison of the improved sirup (right) with the Nickels sirup (left), showing the amount of sirup left in each and the amount of sugar in the Nickels sirup. (Original.)

For the first 4 days the ants showed a preference for the old type of sirup (without the tartaric acid) but for the next 21 days they showed no preference. Then one jar of the old sirup was abandoned. This proved to be partially decomposed. On moving to another spot it was attended for 10 days more, then abandoned completely. Thus for a total of 35 days this jar attracted the ants. Seven days later the other jar of this sirup was abandoned and no matter where placed neither jar had any attraction for the ants.

[1] Figure 3 shows the small quantity of sirup that still remained, as well as the large bulk of sugar crystals which had formed in the jar. The jar containing the acidified sirup is placed at the side for comparison.

The jars with the new type of sirup were visited constantly for 62 days, or to the conclusion of the experiment. The small amount of sirup left was still clean and as sweet as at first.

Tests of the poisonous qualities of both liquids were made with colonies in Janet cages, under control as to food. There was practically no difference in toxicity. Workers in both cages began to die in 4 days, the queens stopped ovipositing in 14 days, and winged males died very quickly, the queens in 17 days, and the whole colony in each case was exterminated on the thirty-second day.

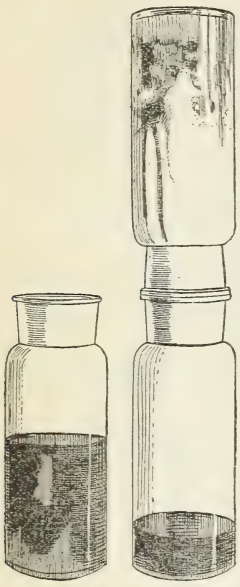

FIG. 3.—Comparison of the improved sirup (left) with the Nickels sirup (right) after five months' evaporation. The improved sirup is still clear and sweet, while the Nickels sirup is dark and full of crystals and decayed matter. (Originak)

PRACTICAL TESTS OF THE IMPROVED SIRUP.

The new sirup, made exactly as in the formula given above, is very palatable to the ants at any season of the year. It was found that containers charged with it placed at selected points outside a residence would attract the ants and they would cease to invade the house. A private residence in a large plot of ground on a street corner with a row of large oak trees along each street was heavily infested with ants, which were to be found in the sink, the refrigerator, all over the floors, etc. On June 18, 6 cans each containing this sirup and a sponge were hung on the brick pillars which supported the house. The following morning there was scarcely an ant to be seen in the house and the ants were attending the sirup in large numbers. The same conditions existed throughout the length of the experiment, which was terminated on August 10. Many such small experiments have been conducted, the results being equally successful.

APPLICATION OF THE SIRUP.

The paraffin-covered paper bag[1] shown in figure 4 is undoubtedly the cheapest container. It can be made in large quantities at a cost of about $5 per thousand. Small 1-pound bags used in grocery stores are obtained, and two or three holes about one-fourth inch in diameter are cut through each folded bag with a leather-punch or similar instrument. This provides each bag with two holes on each side for the entrance of the ants. Being opened, the bags are dipped in a pan of molten

[1] The writer is indebted to Mr. R. W. Moreland, Bureau of Entomology, for his suggestions in the preparation of this waterproof container.

paraffin and set aside to dry. The paraffin, forming a waterproof surface, materially lengthens the life of the bag, which is protected from the entrance of water through the holes by part of another (2-pound) paraffined bag which covers the first one like a canopy. In use, each bag is provided with a small quantity of poisoned sirup and a piece of sponge, the protecting outer piece of bag is drawn up over it, and the ends of both are folded over at the top and tacked to a tree. On account of the bag coming together at the top it is very narrow at the point where the entrance holes are made; consequently very small pieces of sponge are required. The bags have been known to last for long periods, but the larger percentage of them last only about 2 or 3 months. They can not be recharged.

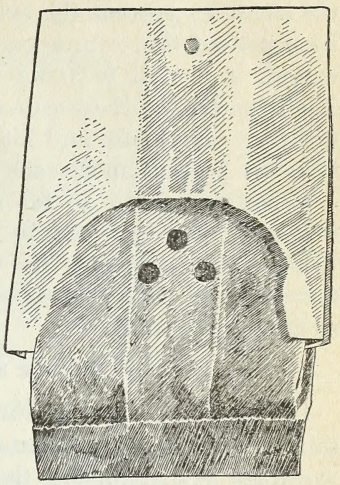

FIG. 4.—Paraffined paper bags arranged as a container for ant poison sirup. The apron has been cut away to show the ant entrance holes. Such bags are nailed to trees. (Original.)

The tin can shown in figure 5 is the most satisfactory container. Any sized can may be used, but the handiest size is the one-half pound baking-powder can. The can must have a friction cover, and of course it must hold water. If the can is indented deeply on the two opposite sides (as illustrated in the drawing, fig. 5) and the cover replaced, it will be observable that there is ample space between the top of the can and the cover for the entrance of the ants, and the can, if kept in an upright position, will be weatherproof. About a gill of the sirup will be sufficient for several months, but in heavy infestations it is better to put 2 gills in each can. It is very advisable to place a fairly large piece of sponge in the can. The sponge will float on the sirup and allow the ants to feed in large numbers. A piece of wire about 6 inches long may be bent for a handle, a hook inward at each end being made. The hooks may be attached under the lid of the can where it projects over the part that has been indented. This forms a handle by which

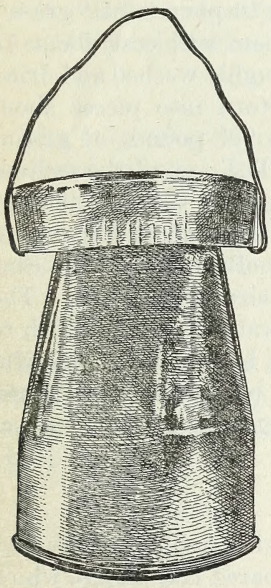

FIG. 5.—Tin can container for ant-poison sirups used in outdoor experiments. (Original.)

the cans may be hung on trees, fences, walls of houses, etc. The ants prefer to climb for their food, and it is well to hang the cans near ant trails going up trees, walls, etc. It is advisable to hang the cans in the shade to prevent the evaporation of the sirup, for though it has been proved that evaporation does not affect this sirup to a marked extent, it is well to avoid raising the solid contents of the liquid. Eight to ten of these cans should be sufficient to place around an ordinary city house and lot. If the grounds are large and if many trees are present, more cans should be placed out.

From the results so far obtained, the careful preparation of the poisoned sirup can not be too highly emphasized. Very accurate balances are necessary for the weighing out of the poison and the tartaric acid. This is especially true when small quantities of the sirup are prepared.

PLANS FOR MUNICIPAL CONTROL WORK.

In effecting control in towns and cities it is first necessary to ascertain the extent of the infestation. This should be mapped out so that workmen in distributing the cans will be able to refer to the map to insure the covering of the entire territory. Cans may be obtained at wholesale at about $16 per thousand. About 10 pounds of "grass" sponges will be required per 1,000 cans. These will cost about 75 cents per pound. The sponges should be thoroughly washed and dried before use. When wet they may easily be torn into pieces about 2 by 2 inches. Using 1 gill of sirup per can, 200 pounds of granulated sugar will be required per 1,000 cans. The cost of the sodium arsenite is about 80 cents per pound, and 1 pound will be sufficient for 1,500 cans. Tartaric acid (crystallized) costs about 70 cents a pound, which will be enough for 4,500 cans. From 60 to 100 cans will be required per block, depending on the size of the block. The late fall, winter, and spring are the most desirable times in which to do this work, as in these seasons the natural food is least plentiful and the ants most hungry. Two men should be able to prepare the sirup, wash and tear up the sponges, and charge about 2,000 cans per day and distribute about 1,000 cans per day.

TRAPPING ANTS.

By taking advantage of their winter colonizing habit the ants may be attracted in large numbers to specially prepared trap boxes, which may be fumigated when large numbers have gathered in these boxes for winter nesting. Newell and Barber, who originated this method of control, describe in Bureau of Entomology Bulletin 122 some very interesting and successful trap-box experiments. The boxes were filled with decaying vegetation, the heat generated making them very attractive as hibernating quarters. Carbon bisulphid was found to

be the best and most economical fumigant for use in the trap boxes. It is hardly necessary to state that this method of control is not applicable to city conditions, where dry nesting quarters are very plentiful and the ants do not colonize to any great extent.

SUMMARY OF CONTROL MEASURES.

ANT BARRIERS.

In grossly infested houses much relief may be secured by isolating tables, refrigerators, safes, beds, etc., with bichlorid-of-mercury tape, or by placing the legs of articles of furniture in saucers filled with moth balls or coal oil. Trees, beehive stands, and other outdoor objects may be isolated with the sticky substance used on fly paper but made thinner than usual. If 5 per cent of carbolized oil be added, the durability of the bands will be considerably increased.

REPELLENT ANT POISONS.

Repellents are much used to keep the ants from buildings. Strong antimony or arsenical sirups, a number of which are sold by druggists in infested territory, are used for this purpose. They give quick relief for short periods, but they are not a factor in the reduction of the infestation.

ATTRACTIVE ANT POISONS.

The only effective poisons yet known for permanent control are poisoned sirups. The improved arsenical sirup recommended on page 18 will not spoil and is superior to any other formula yet tested on account of its stability at high temperatures, freedom from crystallization, and continued attractiveness.

TRAPPING ANTS.

Trapping ants may be accomplished in rural locations by providing boxes of decaying vegetation in the winter. The colonies will move into these boxes and the ants may then be killed with carbon bisulphid.

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